Clastic Dykes in Volcanic Rocks of the Giant Section, Yellowknife NWT.

Hendrik Falck and J. A. Donaldson

Department of Earth Sciences,

Carleton University,

Ottawa, Ontario,

K1S 5B6

NWT GEOLOGY DIVISION - NAP
Box 1500 - Yellowknife

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

EGS 1988-7 Clastic Dykes in Volcanic Rocks of the Giant Section, Yellowknife, NWT
part of NTS 85 J/9
by Hendrik Falck and J.A. Donaldson
1 text

Price: $0.60

Abstract

The Giant Section near Yellowknife offers an unrivalled exposure of Archean volcanic rocks of the Slave Province. Among several unusual features in the Giant Section are six clastic dykes, up to 20 m long and 50 cm wide, that cut across a flow of pillowed basalt. The dykes are infilled by a well-sorted lithic sandstone, as well as sparse fragments of pillows and pillow selvages. Rare laminations within the dykes are sub-parallel to the local bedding, indicating passive infilling of fractures before deformation of the volcanic belt. The source of the dyke sand is inferred to be a sandstone bed that overlies the pillowed flow on the basis of these observations: 1) Two of the dykes coalesce with this upper sandstone bed. 2) All six dykes wedge out downward before reaching the other potential source, an underlying sandstone bed. 3) The dyke infill is compositionally and texturally different from the lower sandstone, but similar to the upper sandstone. Although the dykes most commonly occur between pillows with intact selvages, they also cut through some pillows along fractures that lack chilled margins, and infill rare radial cooling fractures. This suggests that the dykes were formed soon after solidification of the pillowed flow, and before lithification of the overlying sandstone bed.

Introduction

The Giant Section is located within the property of Giant Yellowknife Mines, five kilometres north of the city of Yellowknife. The rocks of the Giant Section belong to the Upper Kam Group of the Yellowknife Greenstone Belt, a succession of mafic and felsic volcanic, volcaniclastic and intrusive rocks plus intercalated sediments, all metamorphosed to greenschist facies (Henderson and Brown, 1966). The belt has been homoclinally folded, and the present erosional surface reveals a cross-section through the volcanic edifice (Helmstaedt et al.,1986). Vertical stretching has occurred, but many primary structures and fabrics are well preserved. Almost free of overburden, the outcrop is also lichen-free, resulting in an excellent locality for the detailed study of primary features typical of Archean terranes. Six clastic dykes that cut across a pillowed lava flow are the focus of this study. These sandstone dykes are unusual in that they occur in volcanic rocks (Padgham,1987). The objectives of this study have been to map the dykes in detail and determine the source of the sediment in the dykes.

Setting

The dyke-bearing pillowed flow is in conformable contact with a massive, fine- to medium- grained sand, that grades into a well-stratified layer displaying climbing ripples, referred to as the "lower sandstone" (Figure 1) (Donaldson et al.,1987). The pillows rest on a thin zone of massive sand, and some pillow interstices are filled with massive to faintly laminated sand connected to this underlying sandstone unit. Some basal pillows appear to "float" in the sandstone. Sediment deposition continued during lava extrusion, as indicated by several discontinuous horizons of crossbedded sandstone, each representing a brief cessation of pillow extrusion, where sand deposition dominated over pillow formation. Preservation of uninterrupted pillow rims

suggests rapid burial; the absence of hyaloclastic fragments provides evidence of strong currents (Padgham, 1980).

The basalt flow is characterized by elongate pillows averaging 1-2 m by .5-1 m. This is the only flow in the area where sedimentary dykes have been observed. The present erosional surface cuts through the steeply dipping pillowed flow subperpendicular to the direction of lava flow. This has resulted in a variety of pillow forms, from globular to elongate tubes. The total thickness of 25-30 m is the composite thickness of several flows. These sub-flows can be defined by differences in pillow size, discontinuous intercalations of sand and by differences in vesicle concentration. Conformably overlying the pillowed flow is another sandstone layer informally called the "upper sandstone". This quartz-rich lithic sandstone is distinctive due to the presence of pebble-sized cherty-felsic fragments. The matrix of the basal portion of the sandstone is a massive medium-grained sandstone. Lenses of pebbly-coarse sandstone occur locally, but these are rare. Hyaloclastite and pillow breccia are absent, and pillow selvages in contact with the sandstone commonly are not complete. Small selvage fragments are contained in the sandstone, suggesting strong currents during sand deposition.

Dyke Character

Six dykes have been mapped along strike in the pillowed flow over a distance of 600 m. The dykes range in thickness from a few mm to over 50 cm. A single dyke has been traced through the flow for over 20 m, but none of the dykes extends beyond the margins of the pillowed flow. Drill holes have not encountered the dykes at depth, and on surface the dykes appear to be laterally restricted to the Giant Section. In most places the dykes are bounded by the outer margins of pillow selvages, but the dykes also cut through pillows and infill cooling fractures.

Where a dyke is between two selvages, it resembles the lower sandstone/pillowed flow contact. However, a number of points indicate that the sand was not present at the time of pillow formation. The pillow selvages adjacent to the sandstone dykes are the same thickness as those adjacent to other pillows. Had water-saturated sand come in contact with newly formed pillows, it probably would have caused more rapid cooling and the formation of thicker selvages. Furthermore, no sand is incorporated into the pillow selvages along the dyke margins. This differs from selvages at the lower sandstone contact, where the lava extruded over the sands, incorporating sand grains into the selvages (Figure 2a).

In the places where a dyke cuts through a pillow core, the margins show no evidence of chilling or extensive reaction between water-saturated sand and lava (Figure 3). In thin section, the boundary between sand and basalt is marked by a thin zone of spilitization and leucoxene formation (Figure 2b). Where sands have infilled radial cooling fractures in a pillow, the dykelets of sand can be traced back to a nearby main dyke. In areas where clastic dykes are absent, cooling fractures do not contain sand grains.

Sediment Source

The composition and characteristics of the upper and lower sandstone provide a basis for determining the source of the sandstone within the dykes. In thin section, the lower sandstone is dominated by subrounded to subangular sand grains cemented by a carbonate/silica/chlorite cement. Most grains are fragments of mafic volcanic rocks that consist of very fine grained mats of intergrown plagioclase, chlorite and epidote, containing a few coarse phenocrysts of plagioclase and quartz. Most plagioclase crystals are partially or completely altered to sericite, and the quartz crystals display embayments and altered rims. Other grains in the sandstone include subrounded quartz

grains, smaller altered plagioclase crystals, sphene and opaque minerals. Hematite-stained veinlets are locally abundant.

The upper sandstone differs most from the lower sandstone in showing a predominance of altered plagioclase grains. Most of the sand grains are angular to subangular. The lithic fragments are smaller but more porphyritic, containing coarser plagioclase crystals. Quartz grains tend to be larger and more angular than their counterparts in the lower sandstone. Epidotized selvage fragments are common. Distinctive polycrystalline to cherty-quartz grains characterize the upper sandstone in hand specimen as well as in thin section. Such grains are absent in the lower sandstone.

Close examination of the sandstone within the dykes reveals that it strongly resembles the upper sandstone in both composition and texture (Figure 3). In addition, the dykes contain numerous pillow fragments and selvage fragments (Figure 4). The selvage fragments are not the typical hyaloclastic fragments associated with autobrecciation, but appear to have been broken from the margins of pillows. In some instances, the fragments have not been transported far, and it is possible to visually reassemble fragments with respect to apparent source pillows.

The internal structure of the dykes does not support the hypothesis of upward injection of sand into the dykes. There is no evidence of size gradation parallel to the fracture walls, as is commonly displayed in clastic dykes emplaced by forceful injection. Most of the dyke fill is massive, with local occurrences of normal grading suggesting rapid deposition. Some crude stratification also is apparent in which the laminations are parallel to the original horizontal (as deduced from the long axes of the pillows and flat drainage cavities). Passive infilling from above best accounts for the internal lamination.

The most conclusive evidence that the upper sandstone is the source of the dyke sediments is the relationship between the dykes and the two sandstone beds. None of the six dykes reaches the lower sandstone: all pinch out before reaching the lower bed. In contrast, two of the six dykes can be traced to the upper sandstone (Figure 5); upper contacts of the other four dykes are not exposed.

Conclusion

Having identified the source of sediment as the overlying sandstone bed, the timing of dyke formation can be constrained. The lack of reaction between the sandstone and the basalt indicates that the basalt had already cooled substantially before emplacement of the dykes. The linear nature of the fracture walls through the centres of pillows further demonstrates their solid nature. Thus, rather than downward loading of sand into still molten lava, the mode of formation is due to the infilling of fractures in a pile of cooled pillowed flows. As the fractures do not extend above the top of the pillowed sequence, dyke formation occurred soon after restoration of the depositional environment of the epiclastic sand.

The lower part of the capping sandstone is massive, but it is conformably overlain by crossbedded sandstone which shows no sign of deformation. Thus, the infilling of the dykes must have occurred before deposition of this stratified sand. The massive nature of the lower part of the sandstone is suspected to be due to extensive soft-sediment deformation triggered by the same event responsible for the formation of the sandstone dykes.

Proximity of the sandstone dykes described here to a 4 m wide basaltic dyke that appears to feed both sills and dykes at the Giant Section suggests a possible relationship between the successive pulses of magmatic intrusion/extrusion and surface fracturing of the flow. With the control on the source of sediment and the timing of the dyke formation having now been established, effort will now be directed at developing a model to explain these relationships.

References

Donaldson, J.A., H. Falck, G. Potts, B. Donaldson and W.A. Padgham 1987 Enhancement of Outcrops of Archean Volcanic and Sedimentary Rocks in the Giant Section Near Yellowknife, NWT. Geological Association of Canada, Summer Meeting Yellowknife (Abstracts).p.

Helmstaedt, H., W.A. Padgham, and J.A. Brophy 1986 Multiple Dykes in the Lower Kam Group, Yellowknife Greenstone Belt: Evidence for Seafloor Spreading? Geology, Vol. 14, P. 562-566.

Henderson, J.F. and I.C. Brown 1966 Geology and Structure of the Yellowknife Greenstone Belt, District of MacKenzie. Geological Survey of Canada Bulletin 141.

Padgham, W.A. 1980 An Archean Ignimbrite at Yellowknife and its Relationship to the Kam Formation Basalts. Precambrian Research, Vol. 12.p. 99-113.

Padgham. W.A. 1987 Yellowknife Guide Book, A guide to the geology of the Yellowknife Volcanic belt and its bordering rocks. Mineral Deposits Division, Geological Association of Canada. p.210.

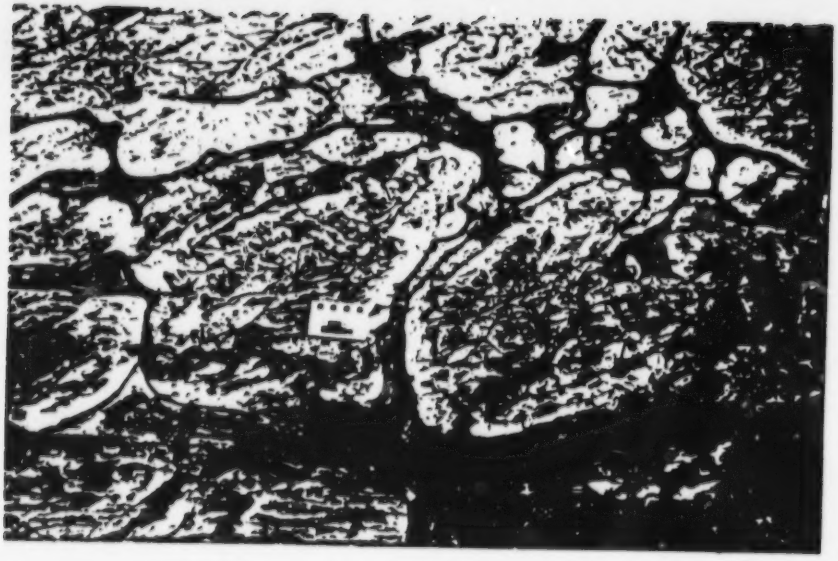
Figure 1. Pillowed flow overlying crossbedded sand showing upward injection of sand between pillows (eg. to right of scale card).

Figure 2. Thin section of a) sandstone dyke/pillow selvage contact. Arrow marks selvage edge.
b) sandstone dyke/fractured pillow contact.

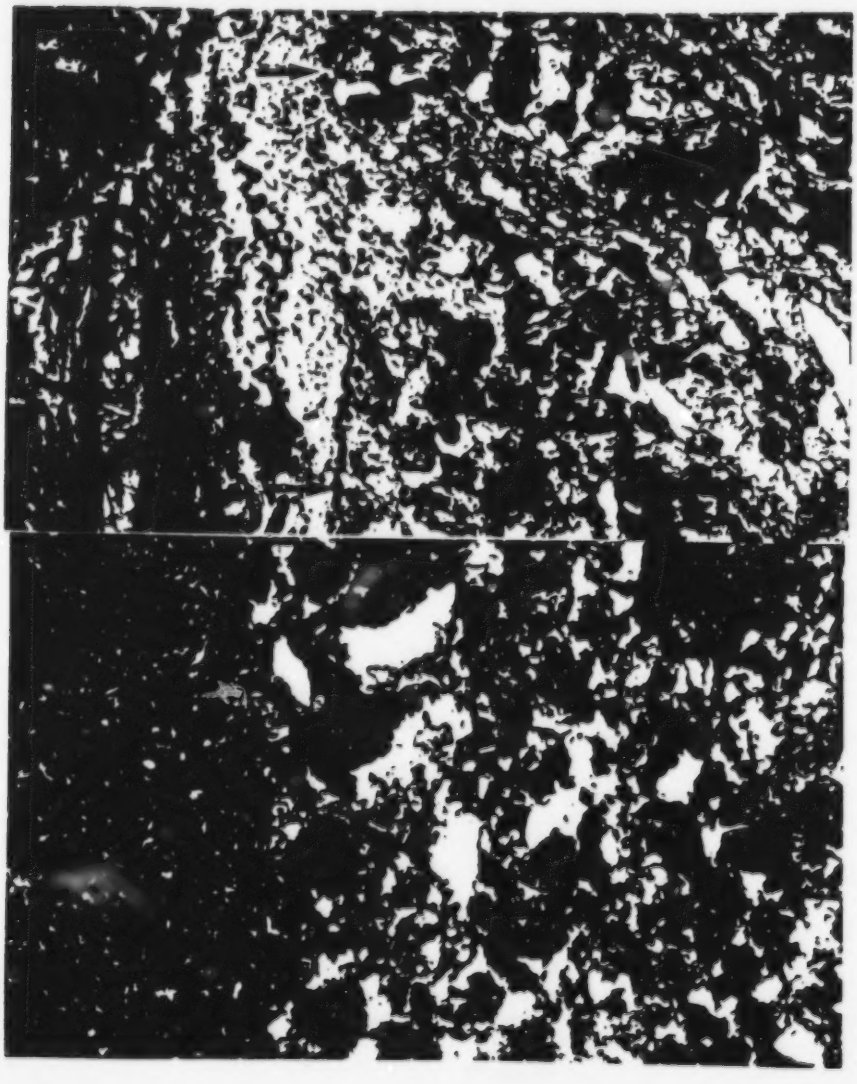
Figure 3. Photo of dyke sandstone displaying the coarse angular fragments characteristic of the upper sandstone. Notice that the fracture walls show no sign of a selvage or chilling.

Figure 4. Sandstone dyke containing numerous pillow and pillow selvage fragments.

Figure 5. Contact between the upper sandstone and the pillowed flow showing continuity of sandstone in the dyke and the overlying bed.



1

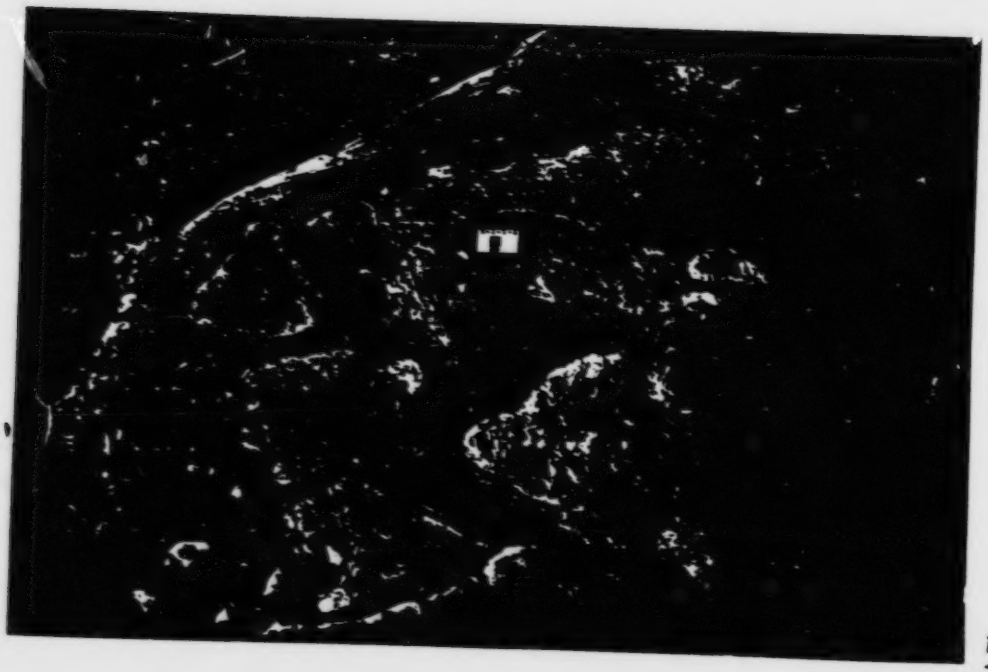


2a

2b

3

4



5